Performance requirements (pressure stress)

INFO Sheet B3

Description:	*Pressure stress in polymeric solar thermal collectors* *Temperature-pressure matrix*
Date:	May 2015
Authors:	T. Ramschak, D. Preiß / AEE INTEC, Gleisdorf, Austria
Download at:	http://task39.iea-shc.org/publications

Introduction

Conventional system behavior during stagnation is well understood and measures to handle this state are known. Nevertheless for economically priced polymer collectors stagnation will be a considerable challenge caused by the high temperature and pressure stress during standstill times of the solar system. In closed systems the pressure development is directly related to the temperature development. Therefore measures to overcome this disadvantage have already been mentioned in the accompanying INFO Sheet B2: "Temperature stress". Open drain-back systems offer the ability to reduce the pressure stress.

Pressure stress in solar thermal collectors with and without overheating protection

Figure 1 depicts the frequency of the calculated pressure stress for the reference- and polymeric systems with overheating protection (OHP) with backcooler (B5) and without OHP as drain-back solution for the application domestic hot water in single-family houses at five reference sites (see B1).

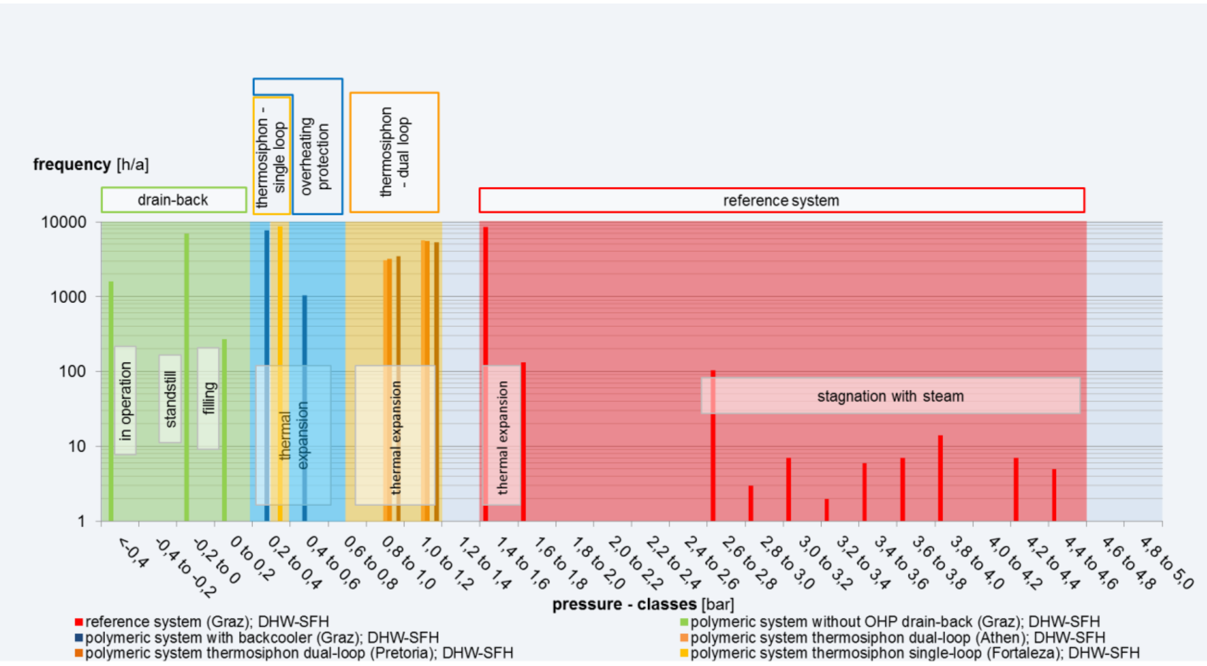

Figure 1: Frequency of pressure stress of polymeric- and reference absorbers for the application "domestic hot water" in single family houses at various sites (excess pressure).

In the closed reference systems (red area) the pressure development depends on different facts: temperature, stagnation behavior of the solar loop and the dimension of the expansion vessel. In systems with active overheating protection (blue area) and dual-loop thermosiphon systems (brown area) evaporation doesn´t take place, so the maximum pressure depends on the thermal expansion of the heat transfer medium. The maximum occurring pressure in atmospheric single-loop thermosiphon systems (yellow area) is corresponding to the geodetic height difference between the storage and the collector. Due to the automatic emptying of the collector and piping in drain-back systems (green area), evaporation can be almost completely avoided. The maximum occurring pressure takes place during the filling process (geodetic height of the collector approx. 2 m). However, during operation there will be a negative pressure caused by the suction effect (geodetic height difference between collector and drain-back tank) of the flow pipe.

The following matrix (Table 1) summarizes the temperature- and pressure stress levels of the regarded solar thermal systems in the INFO Sheets (B1) “Reference systems”, (B2) “Temperature stress” and (B3) “Pressure stress”. The frequencies of the temperature have been summarized to larger temperature classes. The corresponding values of the pressure are in the same column.

Table 1: Pressure and temperature matrix (more precise data are available on request)

application ↓	temperature classes →	<0 [°C] frequency [h/a]	<0 [°C] pressure min [bar abs.]	<0 [°C] pressure max [bar abs.]	0 to 75 [°C] frequency [h/a]	0 to 75 [°C] pressure min [bar abs.]	0 to 75 [°C] pressure max [bar abs.]	75 to 100 [°C] frequency [h/a]	75 to 100 [°C] pressure min [bar abs.]	75 to 100 [°C] pressure max [bar abs.]	100 to 125 [°C] frequency [h/a]	100 to 125 [°C] pressure min [bar abs.]	100 to 125 [°C] pressure max [bar abs.]	125 to 150 [°C] frequency [h/a]	125 to 150 [°C] pressure min [bar abs.]	125 to 150 [°C] pressure max [bar abs.]	150 to 175 [°C] frequency [h/a]	150 to 175 [°C] pressure min [bar abs.]	150 to 175 [°C] pressure max [bar abs.]	175 to 200 [°C] frequency [h/a]	175 to 200 [°C] pressure min [bar abs.]	175 to 200 [°C] pressure max [bar abs.]	>200 [°C] frequency [h/a]	>200 [°C] pressure min [bar abs.]	>200 [°C] pressure max [bar abs.]
Domestic hot water - SFH	reference system pumped; (Graz)	1059	2,46	2,47	7431	2,47	2,61	86	2,61	2,67	25	2,68	2,74	39	2,74	3,88	72	3,70	4,72	48	3,70	5,45	0	-	-
	polymeric system without OHP; drain-back (Graz)	978	0,60	1,14	7337	0,60	1,14	171	0,60	1,14	148	1,00	1,00	107	1,00	1,00	19	1,00	1,00	0	-	-	0	-	-
	polymeric system with OHP; backcooler (Graz)	1125	1,27	1,31	7462	1,29	1,51	173	1,49	1,57	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
	polymeric system thermosiphon; dual-loop (Pretoria)	0	-	-	8564	0,98	1,08	196	1,08	1,09	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
	polymeric system thermosiphon; single-loop (Fortaleza)	0	-	-	8347	1,40	1,40	413	1,40	1,40	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
	polymeric system thermosiphon; dual-loop (Peking)	1021	0,97	0,97	7589	0,98	0,98	150	1,08	1,09	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
	polymeric system thermosiphon; dual-loop (Athen)	0	-	-	8456	0,98	1,08	304	1,08	1,09	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
Combi system - SFH	reference system pumped; (Graz)	1054	2,68	2,69	6791	2,69	2,76	547	2,76	2,79	73	2,79	2,83	106	2,83	4,43	101	4,25	5,40	86	4,25	5,40	2	4,25	4,25
	polymeric system without OHP; drain-back (Graz)	970	0,60	1,14	7047	0,60	1,14	455	0,60	1,14	149	1,00	1,00	116	1,00	1,00	23	1,00	1,00	0	-	-	0	-	-
	polymeric system with OHP; backcooler (Graz)	1123	1,26	1,29	7243	1,29	1,54	394	1,53	1,61	0	-	-	0	-	-	0	-	-	0	-	-	0	-	-
	polymeric system without OHP; drain-back (Athen)	0	-	-	7697	0,60	1,14	484	0,60	1,14	267	1,00	1,00	268	1,00	1,00	44	1,00	1,00	0	-	-	0	-	-
Domestic hot water - MFH	polymeric system without OHP; drain-back (Graz)	975	0,60	1,14	7524	0,60	1,14	186	0,60	1,14	54	1,00	1,00	21	1,00	1,00	0	-	-	0	-	-	0	-	-
	polymeric system without OHP; drain-back (Peking)	1007	0,60	1,14	7413	0,60	1,14	183	0,60	1,14	139	1,00	1,00	18	1,00	1,00	0	-	-	0	-	-	0	-	-

References

Kaiser A., Hausner R., Ramschak T., Streicher W. (2013) Leistungsanforderungen an Polymermaterialien in solarthermischen Systemen, EE-Zeitschrift für eine nachhaltige Energiezukunft 2013-1:12-16, Gleisdorf, Austria